

Appl. No. 09/853,913
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 Reply to Office Action of December 21, 2005

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Amendments to the Claims:

This listing of claims will replace all prior versions, and listings of claims in the application:

Listing of Claims:

1 Claims 1.-9. (canceled).

1 Claim 10. (currently amended) A method performed by a custodian computing
 2 system, having memory, to share a secret S among n secret owners such that any k of the n secret
 3 owners may reconstruct the secret S , the method comprising the steps of:

4 choosing two large primes P and Q , such that PQ is greater than S when S is a
 5 number;

6 ~~computing, at the custodian computing system, and storing in the custodian~~
 7 ~~computer system memory a product $N = PQ$;~~

8 ~~computing and storing a product $M = (P-1)(Q-1)$;~~

9 choosing n random numbers e_1 through e_n that are relatively prime to N ;

10 choosing another random number e that is relatively prime to N ;

11 choosing n numbers d_1 through d_n such that $e_i d_i \bmod M$ equals one for $1 \leq i \leq n$;

12 choosing another number d such that $ed \bmod M$ is equal to one;

13 ~~generating and storing a database of $\binom{n}{k}$ values, where each value is the product~~

14 ~~of d and a unique k of the d_i numbers for $1 \leq i \leq n$, wherein each value is associated with a~~

15 ~~unique combination of k secret owners of the n secret owners;~~

16 storing a database of $\binom{n}{k}$ entries, wherein each entry is associated with a unique

17 combination of the $\binom{n}{k}$ possible combinations of the k secret owners, and wherein a particular

18 entry includes a value, c , that is the product of modulus M of d and the d_i values for i indices that

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19 correspond to the particular secret owners present in the unique combination for that particular
 20 entry, wherein c corresponds to modulus M of the product kdi ;
 21 computing S^c ;
 22 deleting from the custodian computer memory P , Q , and M ;
 23 computing S^c ;
 24 distributing n secret owner pieces to each of the n secret owners, wherein each of
 25 the secret owner pieces includes S^c and one of the numbers e_1 through e_n ;
 26 deleting the secret S and e_1 through e_n , d_1 through d_n , and d ;
 27 receiving k secret owner values from a unique combination of k secret owners;
 28 determining a the value c that is associated with the unique combination; and
 29 determining the secret S using the value c retrieved from the database entry
 30 corresponding to the k secret owners whose secret owner pieces have been received and the k
 31 secret owner values and $S^c \bmod N$.

1 Claim 11. (previously presented) A method as in claim 10, wherein receiving k
 2 secret owner values from the unique combination of k secret owners comprises:
 3 receiving a first of the n secret owner pieces from one of the n secret owners; and
 4 computing and storing $S' = S^{ef} \bmod N$, where f represents the one of the numbers
 5 e_1 through e_n contained in the first of the n secret owner pieces.

1 Claim 12. (previously presented) A method as in claim 11, wherein receiving k
 2 secret owner values from the unique combination of k secret owners comprises:
 3 receiving a second of the n secret owner pieces from another one of the n secret
 4 owners;
 5 computing $S^q \bmod N$, where q represents the one of the numbers e_1 through e_n
 6 contained in the second of the n secret owner pieces; and replacing S' with $S^q \bmod N$.

1 Claim 13. (previously presented) A method as in claim 12, wherein receiving k
 2 secret owner values from the unique combination of k secret owners comprises:

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3 each time another of the secret owner pieces is received from another one of the
 4 secret owners;
 5 computing $S^q \bmod N$, where q represents the one of the numbers e_1 through e_n
 6 contained in the another of the n secret owner pieces; and replacing S' with $S^q \bmod N$.

1 Claim 14. (previously presented) A method as in claim 13, further comprising
 2 the steps of:

3 after k secret owner pieces have been received,
 4 retrieving from the database the value c from among the $\binom{n}{k}$ values, wherein the
 5 value c corresponds to the k secret owner pieces of the unique combination of k secret owners
 6 that were received by the custodian;
 7 computing $S^c \bmod N$; and
 8 replacing S' with $S^c \bmod N$.

1 Claim 15. (currently amended) A method performed by a custodian computing
 2 system, having memory, to share a secret S among n secret owners such that any k of the n secret
 3 owners may reconstruct the secret, the method comprising the steps of:

4 choosing two large primes P and Q , such that PQ is greater than S where S is a
 5 number;
 6 ~~computing, at the custodian computing system, and~~ storing in the custodian
 7 computer memory a product $N = PQ$;
 8 ~~computing and~~ storing a product $M = (P-1)(Q-1)$;
 9 choosing n random numbers e_1 through e_n that are relatively prime to N ;
 10 choosing random numbers e and e' that are relatively prime to N ;
 11 choosing n numbers d_1 through d_n such that $e_i d_i \bmod M$ equals one for $1 \leq i \leq n$;
 12 choosing numbers d and d' such that $ed \bmod M$ is equal to one and such that $e'd'$
 13 $\bmod M$ is equal to one;

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14 ~~generating and storing a database of $\binom{n}{k}$ values, where each value is the product~~
 15 ~~of d and a unique k of the d_i numbers for $1 \leq i \leq n$, wherein each value is associated with a~~
 16 ~~unique combination of k secret owners of the n secret owners;~~
 17 storing a database of $\binom{n}{k}$ entries, wherein each entry is associated with a unique
 18 combination of the $\binom{n}{k}$ possible combinations of the k secret owners, and wherein a particular
 19 entry includes a value, c , that is the product of modulus M of d and the d_i values for i indices that
 20 correspond to the particular secret owners present in the unique combination for that particular
 21 entry, wherein c corresponds to modulus M of the product $k d_i$;
 22 computing $S^{ee'}$;
 23 deleting from the custodian computer memory P , Q , and M ;
 24 computing $S^{ee'}$;
 25 distributing n secret owner pieces to each of the n secret owners, wherein each of
 26 the secret owner pieces includes $S^{ee'}$ and one of the numbers e_1 through e_n ;
 27 deleting the secret S and e_1 through e_n , d_1 through d_n , and d
 28 receiving k secret owner values from a unique combination of k secret owners;
 29 determining retrieving from the database a the value c that is associated with the
 30 unique combination; and
 31 determining the secret S using the value c and the k secret owner value.

1 Clair 16. (previously presented) A method as in claim 15, wherein receiving k
 2 secret owner values from the unique combination of k secret owners comprises:
 3 receiving a first of the n secret owner pieces from one of the n secret owners; and
 4 computing and storing $S' = S^{ee'f} \bmod N$, where f represents the one of the numbers
 5 e_1 through e_n contained in the first of the n secret owner pieces.

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1 Claim 17. (previously presented) A method as in claim 16, wherein receiving k
 2 secret owner values from the unique combination of k secret owners comprises:
 3 receiving a second of the n secret owner pieces from another one of the n secret
 4 owners;
 5 computing $S^q \bmod N$, where q represents the one of the numbers e_1 through e_n
 6 contained in the second of the n secret owner pieces; and replacing S' with $S^q \bmod N$.

1 Claim 18. (previously presented) A method as in claim 17, wherein receiving k
 2 secret owner values from the unique combination of k secret owners comprises:
 3 each time another of the secret owner pieces is received from another one of the n
 4 secret owners;
 5 computing $S^q \bmod N$, where q represents the one of the numbers e_1 through e_n
 6 contained in the another of the n secret owner pieces; and replacing S' with $S^q \bmod N$.

1 Claim 19. (previously presented) A method as in claim 18, further comprising
 2 the steps of:
 3 after k secret owner pieces have been received,
 4 retrieving from the database the value c from among the $\binom{n}{k}$ values, wherein the
 5 value c corresponds to the k secret owner pieces from the unique combination of k secret owners
 6 that were received by the custodian;
 7 computing $S^c \bmod N$;
 8 replacing S' with $S^c \bmod N$;
 9 computing $S^{d'} \bmod N$; and
 10 replacing S' with $S^{d'} \bmod N$.

1 Claim 20. (currently amended) A method performed by a custodian computing
 2 system, having memory, to share a secret among n secret owners such that any k of the n secret
 3 owners may reconstruct the secret, the method comprising the steps of:

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4 encrypting the secret so as to generate an encrypted secret;
 5 deleting from the custodian computer memory the secret; and
 6 performing a forward k out of n secret sharing algorithm on the encrypted secret
 7 so as to generate n secret owner pieces;
 8 storing in a database a plurality of values entries associated with a plurality of
 9 unique combinations of k secret owners of the n secret owners, wherein a particular entry
 10 includes a value, c , that is the product of modulus M of d and the d_i values for i indices that
 11 correspond to the particular secret owners present in the unique combination for that particular
 12 entry, wherein c corresponds to modulus M of the product kdi ;
 13 distributing the n secret owner pieces to the n secret owners;
 14 receiving k secret owner values from a unique combination of k secret owners;
 15 ~~determining~~ retrieving from the database a value c that is associated with the
 16 unique combination;
 17 performing a reverse k out of n secret sharing algorithm on the k secret owner
 18 pieces so as to recreate the encrypted secret using the value c ; and
 19 decrypting the encrypted secret so as to recreate the secret.

Claims 21. - 24. (canceled).

1 Claim 25. (original) A method as in claim 20, wherein the step of performing a
 2 forward k out of n secret sharing algorithm includes the steps of:
 3 dividing the encrypted secret into k pieces; and
 4 performing n polynomial evaluations at n points of a degree- k polynomial using
 5 the k pieces of the encrypted secret as polynomial coefficients;
 6 wherein each of the k secret owner pieces includes a result of one of the n
 7 polynomial evaluations and a corresponding one of the n points.

1 Claim 26. (previously presented) A method as in claim 25, wherein the step of
 2 performing a reverse k out of n secret sharing algorithm includes the steps of generating a system

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3 of k linear equations and solving the system of k linear equations for the k pieces of the encrypted
 4 secret.

1 Claim 27. (previously presented) A method as in claim 26, further comprising
 2 the step of:
 3 assembling the k pieces of the encrypted secret so as to recreate the encrypted
 4 secret.

Claims 28.-29. (canceled).

1 Claim 30. (currently amended) A computer readable storage medium having
 2 embodied thereon computer readable program code suitable for programming a computer to
 3 perform a method performed by a custodian to share a secret S among n secret owners such that
 4 any k of the n secret owners may reconstruct the secret, the method comprising the steps of:
 5 choosing two large primes P and Q , such that PQ is greater than S where S is a
 6 number;
 7 computing and storing a product $N = PQ$;
 8 computing and storing a product $M = (P-1)(Q-1)$;
 9 choosing n random numbers e_1 through e_n that are relatively prime to N ;
 10 choosing another random number e that is relatively prime to N ;
 11 choosing n numbers d_1 through d_n such that $e_i d_i \bmod M$ equals one for $1 \leq i \leq n$;
 12 choosing another number d such that $ed \bmod M$ is equal to one;
 13 generating and storing a database of $\binom{n}{k}$ values, where each value is the product
 14 of d and a unique k of the d_i numbers for $1 \leq i \leq n$, wherein each value is associated with a
 15 unique combination of k secret owners of the n secret owners;

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16 storing a database of $\binom{n}{k}$ entries, wherein each entry is associated with a unique
 17 combination of the $\binom{n}{k}$ possible combinations of the k secret owners, and wherein a particular
 18 entry includes a value, c, that is the product of modulus M of d and the d_i values for i indices that
 19 correspond to the particular secret owners present in the unique combination for that particular
 20 entry, wherein c corresponds to modulus M of the product $k d_i$;
 21 computing S^e ;
 22 deleting P, Q, and M;
 23 computing S^e ;
 24 distributing n secret owner pieces to each of the n secret owners, wherein each of
 25 the secret owner pieces includes S^e and one of the numbers e_1 through e_n ;
 26 deleting the secret S and e_1 through e_n , e , d_1 through d_n , and d;
 27 receiving k secret owner values from a unique combination of k secret owners;
 28 determining retrieving from the database one of the a values c that is associated
 29 with the unique combination; and
 30 determining the secret S using the value c and the k secret owner values.

1 Claim 31. (currently amended) A computer readable storage medium having
 2 embodied thereon computer readable program code suitable for programming a computer to
 3 perform a method performed by a custodian to share a secret S among n secret owners such that
 4 any k of the n secret owners may reconstruct the secret, the method comprising the steps of:
 5 choosing two large primes P and Q, such that PQ is greater than S where S is a
 6 number;
 7 ~~computing and storing a product $N = PQ$;~~
 8 ~~computing and storing a product $M = (P-1)(Q-1)$;~~
 9 choosing n random numbers e_1 through e_n that are relatively prime to N;
 10 choosing random numbers e and e' that are relatively prime to N;

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11 choosing n numbers d_1 through d_n such that $e_i d_i \bmod M$ equals one for $1 \leq i \leq n$;
 12 choosing numbers d and d' such that $ed \bmod M$ is equal to one and such that $e'd'$
 13 $\bmod M$ is equal to one;
 14 generating and storing a database of $\binom{n}{k}$ values, where each value is the product
 15 of d and a unique k of the d_i numbers for $1 \leq i \leq n$, wherein each value is associated with a
 16 unique combination of k secret owners of the n secret owners;
 17 storing a database of $\binom{n}{k}$ entries, wherein each entry is associated with a unique
 18 combination of the $\binom{n}{k}$ possible combinations of the k secret owners, and wherein a particular
 19 entry includes a value, c , that is the product of modulus M of d and the d_i values for i indices that
 20 correspond to the particular secret owners present in the unique combination for that particular
 21 entry, wherein c corresponds to modulus M of the product kdi ;
 22 computing $S^{ee'}$;
 23 deleting P , Q , and M ;
 24 computing $S^{ee'}$;
 25 distributing n secret owner pieces to each of the n secret owners, wherein each of
 26 the secret owner pieces includes $S^{ee'}$ and one of the numbers e_1 through e_n ;
 27 deleting the secret S and e_1 through e_n , d_1 through d_n , and d ;
 28 receiving k secret owner values from a unique combination of k secret owners;
 29 determining retrieving from the database one of the a values c that is associated
 30 with the unique combination; and
 31 determining the secret S using the value c and the k secret owner values.

1 Claim 32. (currently amended) A computer readable storage medium having
 2 embodied thereon computer readable program code suitable for programming a computer to

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perform a method performed by a custodian to share a secret among n secret owners such that any k of the n secret owners may reconstruct the secret, the method comprising the steps of:

- encrypting the secret so as to generate an encrypted secret;
- deleting the secret;
- performing a forward k out of n secret sharing algorithm on the encrypted secret so as to generate n secret owner pieces;
- storing in a database a plurality of values entries associated with a plurality of unique combinations of k secret owners of the n secret owners, wherein a particular entry includes a value, c , that is the product of modulus M of d and the d_i values for i indices that correspond to the particular secret owners present in the unique combination for that particular entry, wherein c corresponds to modulus M of the product $k d_i$;
- distributing the n secret owner pieces to the n secret owners;
- receiving k secret owner values from a unique combination of k secret owners;
- ~~determining~~ retrieving from the database one of the a values c that is associated with the unique combination;
- performing a reverse k out of n secret sharing algorithm on the k secret owner pieces so as to recreate the encrypted secret using the value c ; and
- decrypting the encrypted secret so as to recreate the secret.

Claims 33.-34. (canceled).

Claim 35. (currently amended) A computer comprising a processor and a computer readable storage medium coupled to the processor having embodied thereon processor readable program code suitable for programming a computer to perform a method performed by a custodian to share a secret S among n secret owners such that any k of the n secret owners may reconstruct the secret, the method comprising the steps of:

- choosing two large primes P and Q , such that PQ is greater than S where S is a number;
- ~~computing and storing~~ a product $N = PQ$;
- ~~computing and storing~~ a product $M = (P-1)(Q-1)$;

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10 choosing n random numbers e_1 through e_n that are relatively prime to N ;
 11 choosing another random number e that is relatively prime to N ;
 12 choosing n numbers d_1 through d_n such that $e_i d_i \bmod M$ equals one for $1 \leq i \leq n$;
 13 choosing another number d such that $ed \bmod M$ is equal to one;
 14 ~~generating and storing a database of $\binom{n}{k}$ values, where each value is the product~~
 15 ~~of d and a unique k of the d_i numbers for $1 \leq i \leq n$, wherein each value is associated with a~~
 16 ~~unique combination of k secret owners of the n secret owners;~~
 17 storing a database of $\binom{n}{k}$ entries, wherein each entry is associated with a unique
 18 combination of the $\binom{n}{k}$ possible combinations of the k secret owners, and wherein a particular
 19 entry includes a value, c , that is the product of modulus M of d and the d_i values for i indices that
 20 correspond to the particular secret owners present in the unique combination for that particular
 21 entry, wherein c corresponds to modulus M of the product $k d_i$;
 22 computing S^e ;
 23 deleting P , Q , and M ;
 24 computing S^e ;
 25 distributing n secret owner pieces to each of the n secret owners, wherein each of
 26 the secret owner pieces includes S^e and one of the numbers e_1 through e_n ;
 27 deleting the secret S and e_1 through e_n , e , d_1 through d_n , and d ;
 28 receiving k secret owner values from a unique combination of k secret owners;
 29 determining retrieving from the database one of the a values c that is associated
 30 with the unique combination; and
 31 determining the secret S using the value c and the k secret owner values.

1 Claim 36. (currently amended) A computer comprising a processor and a
 2 computer readable storage medium coupled to the processor having embodied thereon processor

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readable program code suitable for programming the computer to perform a method performed by a custodian to share a secret S among n secret owners such that any k of the n secret owners may reconstruct the secret, the method comprising the steps of:

choosing two large primes P and Q , such that PQ is greater than S where S is a number;

~~computing and storing~~ a product $N = PQ$;

~~computing and storing~~ a product $M = (P-1)(Q-1)$;

choosing n random numbers e_1 through e_n that are relatively prime to N ;

choosing random numbers e and e' that are relatively prime to N ;

choosing n numbers d_1 through d_n such that $e_i d_i \bmod M$ equals one for $1 \leq i \leq n$;

choosing numbers d and d' such that $ed \bmod M$ is equal to one and such that $e'd' \bmod M$ is equal to one;

generating and storing a database of $\binom{n}{k}$ values, where each value is the product of d and a unique k of the d_i numbers for $1 \leq i \leq n$, wherein each value is associated with a unique combination of k secret owners of the n secret owners;

storing a database of $\binom{n}{k}$ entries, wherein each entry is associated with a unique

combination of the $\binom{n}{k}$ possible combinations of the k secret owners, and wherein a particular

entry includes a value, c , that is the product of modulus M of d and the d_i values for i indices that correspond to the particular secret owners present in the unique combination for that particular entry, wherein c corresponds to modulus M of the product $k d_i$;

computing $S^{ee'}$;

deleting P , Q , and M ;

~~computing $S^{ee'}$;~~

distributing n secret owner pieces to each of the n secret owners, wherein each of the secret owner pieces includes $S^{ee'}$ and one of the numbers e_1 through e_n ;

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28 deleting the secret S and e_1 through e_n , d_1 through d_n , and d ;
 29 receiving k secret owner values from a unique combination of k secret owners;
 30 ~~determining~~ retrieving from the database one of the a values c that is associated
 31 with the unique combination; and
 32 determining the secret S using the value c and the k secret owner values.

1 Claim 37. (currently amended) A computer comprising a processor and a
 2 computer readable storage medium coupled to the processor having embodied thereon processor
 3 readable program code suitable for programming the computer to perform a method performed
 4 by a custodian to share a secret among n secret owner such that any k of the n secret owners may
 5 reconstruct the secret, the method comprising the steps of:
 6 encrypting the secret so as to generate an encrypted secret;
 7 deleting the secret;
 8 performing a forward k out of n secret sharing algorithm on the encrypted secret
 9 so as to generate n secret owner pieces;
 10 storing in a database a plurality of values entries associated with a plurality of
 11 unique combinations of k secret owners of the n secret owners, wherein a particular entry
 12 includes a value, c , that is the product of modulus M of d and the d_i values for i indices that
 13 correspond to the particular secret owners present in the unique combination for that particular
 14 entry, wherein c corresponds to modulus M of the product $k d_i$;
 15 distributing the n secret owner pieces to the n secret owners;
 16 receiving k secret owner values from a unique combination of k secret owners;
 17 ~~determining~~ retrieving from the database one of the a values c that is associated
 18 with the unique combination;
 19 performing a reverse k out of n secret sharing algorithm on the k secret owner
 20 pieces so as to recreate the encrypted secret using the value c ; and
 21 decrypting the encrypted secret so as to recreate the secret.